ENERGY USE ENGINEERING DEPARTMENT

ENERGY CONSERVATION DIVISION

B.C. HYDRO AND POWER AUTHORITY

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ENERGY USE ENGINEERING DEPARTMENT
ENERGY CONSERVATION DIVISION
B.C. HYDRO AND POWER AUTHORITY

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PROJECT 8232

200 WATT HIGH PRESSURE SODIUM TEST

SYNOPSIS:

The B. C. Hydro overhead roadway lighting system presently uses 8,314 four hundred watt mercury vapour luminaires having a total demand of 3,741 kW. The replacement of these luminaires with 200 watt high pressure sodium will result in a demand and annual energy saving of 1,663 kW and 6,650,000 kW.h.

Since 200 W HPS lamps and luminaires are now available from a number of manufacturers, an evaluation, utilizing this equipment, was conducted on Station Street in Duncan, B. C. The HPS system reduced actual energy use by 45% and increased average illuminance.

PROJECT:

Initiated/Requested by:	R. F. Hughes
Date Completed:	1 June 1984
Completed by:	O. Stevens
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EN(GY USE ENGINEERING DEPAR(ENT

PROJECT SUMMARY

PROJECT No. 8232 PRIORITY 2

TITLE: 200 watt High Pressure Sodium Test
Duncan, B.C.

INITIATED/REQUESTED BY: R.F. Hughes

ASSIGNED TO: O.B. Stevens ASSIGNED BY: R.F. Hughes

DATE ASSIGNED: 82/12 DATE REQUIRED: April 2, 1983

ESTIMATED COMPLETION: 83/3 COMPLETED: 1 June 1984

OBJECTIVES AND NOTES:

A 200 watt high pressure sodium light source is now available as a direct alternative to 400 watt mercury vapour. Significant energy savings can be achieved on our overhead roadway lighting system if existing 400 watt mercury vapour luminaires were replaced with the new 200 watt HPS luminaire. To evaluate the new light source and different available refractors a test installation was installed on Station Street in Duncan.

Evaluate the test installation and advise on the type of equipment and advantages of Hydro adding this luminaire to rate schedule 1701.

COPIES TO: DEPARTMENT MANAGER (THEN RECORD FILE), BLUE FILE, SUPERVISOR,
W. Stockton (Duncan District Manager)
A. Gibson H. Simpson
S. Hicks R.M. Schneider

PLEASE ADVISE AS SOON AS POSSIBLE IF CHANGES ARE REQUIRED ABOVE

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SUMMARY

There are presently 8,314 four hundred watt mercury vapour luminaires used in the B. C. Hydro overhead roadway lighting system. With each of the luminaires requiring a total of 450 watts, the total demand is 3,741 kW. Replacing each of these 400 watt mercury vapour luminaires with a 200 watt high pressure sodium luminaire, requiring 250 watts, will result in a demand saving of 1,663 kW and, based on an annual estimated operation of 4,000 hours, energy savings of 6,650,000 kW.h.

Eleven 200 watt high pressure sodium lamps (HPS) using two different streetlighting luminaires (Westinghouse OV-25 luminaires with standard refractors, and special sag glass refractors) were installed, tested and evaluated against a typical 400 watt mercury vapour overhead roadway lighting system in Duncan, B. C. The HPS system reduced actual energy use by 45%, and increased overall average illuminance by 31% for the standard refractor and 12% for the sag glass refractor.

RECOMMENDATIONS

1. 200 watt HPS luminaire should be used in new roadway lighting installations instead of 400 watt mercury vapour.

2. 200 watt HPS lamps in luminaires with standard refractors should be added to the roadway lighting rate schedule 1701.

3. The sag glass refractor is not recommended as an option because when tested the unit did not offer any additional benefits to justify its 40% premium cost.

4. That B. C. Hydro recognize that the replacement of 400 watt mercury vapour luminaires now being used in overhead roadway lighting installations with 200 watt high pressure sodium luminaires will save 6,650,000 kW.h annually.

INTRODUCTION

B. C. Hydro has been replacing lower wattage mercury vapour luminaires with 100 and 150 watt HPS. However, there was no direct replacement for the popular 400 watt mercury lamp. A 200 watt high pressure sodium lamp, which is approximately equal in lumen output to a 400 watt mercury vapour lamp and suitable roadway lighting luminaires are now available from a number of manufacturers. If the 400 watt mercury vapour luminaires in our overhead roadway lighting system were replaced by 200 watt high pressure sodium luminaires, significant energy and demand savings could be achieved.

200 watt HPS lamps, using two different available refractors, were installed and tested in a typical overhead roadway lighting installation. An evaluation was carried out to advise on the type of equipment and advantages for B. C. Hydro to add a 200 watt HPS luminaire to rate schedule 1701.

The objective of this report is to:

1) detail the tests done;

2) evaluate the measurements taken;

3) determine the feasibility of adding a 200 watt HPS luminaire to the B. C. Hydro overhead roadway lighting fixture schedule of Rate 1701;

4) recommend the type of refractor to be used if the HPS system is incorporated into the fixture schedule.

WORK INVOLVED

Station Street, between Canada and Government Avenues in Duncan was selected as the 200 watt high pressure sodium luminaire test location because:

1) the lighting system on this street is typical of the many existing roadway lighting systems that are installed and maintained by B. C. Hydro;

2) the lighting system consisted of 400 watt mercury vapour luminaires which allowed a good comparison with the HPS;

3) street work, including pole replacement, provided an opportunity to have the existing luminaires cleaned and relamped for minimal cost;

4) the street is short and the luminaire placement keeps spillover light from the other streets to a minimum;

5) there is little night traffic which meant the disruption to residents and testing personnel was small;

6) the new lighting system enhanced the areas urban renewal plans.

The existing 400 watt mercury vapour system was returned to a like-new condition by cleaning and relamping the luminaires when the road was resurfaced and the new concrete poles were installed. A more objective comparison between the mercury vapour and high pressure sodium lighting was now possible since both systems would be tested in a similar state.

The new mercury lamps were allowed a burn-in time and then the system was evaluated (see Figure 1 for conditions of test) in accordance with "LM-50 IES Guide for Photometric Measurement of Roadway Lighting

Installations" (Appendix I). However, the spacing to determine average illuminance, as set out in this standard, was extended from 10 to 20 feet because taking 124 measurement was considered excessive (see Figures 2 and 4 for details of test locations).

Figure 1: Conditions of 400 Watt Mercury Vapour System Test

DATE: 12 July 1982
TIME: 2330
CITY: Duncan
LOCATION: Station Street
APPARENT DIRT ACCUMULATION: None
WEATHER: Clear
LAMP WATTAGE: 400 W
LAMP TYPE: Mercury Vapour
PHOTOMETER USED: Tektronix J-16

Luminaires were cleaned and relamped the week of 9 July 1982.
Luminaire #4 had a new lamp installed at 2300, 12 July 1982.

Figure 2: Details of Test Locations

Row A is 4.1 m from curb
Row B is 4.1 m from curb
Row Z is directly below luminaires 2 & 4
Row Y is in centre of roadway
Row X is directly below luminaire 3
Column 1 is 3.0 m from luminaire 2
Column 2 is 6.1 m from Column 1, etc.
Column 40 & 42 are in line with luminaires 2 & 3 respectively
Column 41 is midway between luminaires 2 & 3
Column 50 & 52 are in line with luminaires 7 & 8 respectively
Column 51 is midway between luminaires 7 & 8
(see attached sketch).

Following this test, the mercury vapour system was removed and the high pressure sodium luminaires were installed. The two different luminaires used were:

1) a Westinghouse OV25, Type II, medium cutoff luminaire with a standard refractor;

2) a Westinghouse OV25, Type II, medium cutoff luminaire with a special reflector and sag glass refractor.

This sag glass refractor was claimed to reduce glare and provide more even illuminance levels when used with uneven pole spacing.

After the lamp burn-in time, the high pressure sodium system was tested (see Figure 3 for conditions of test) according to "LM-50" (Appendix 1). The same measurement locations as used for the mercury vapour tests were used to allow an accurate comparison of the two systems.

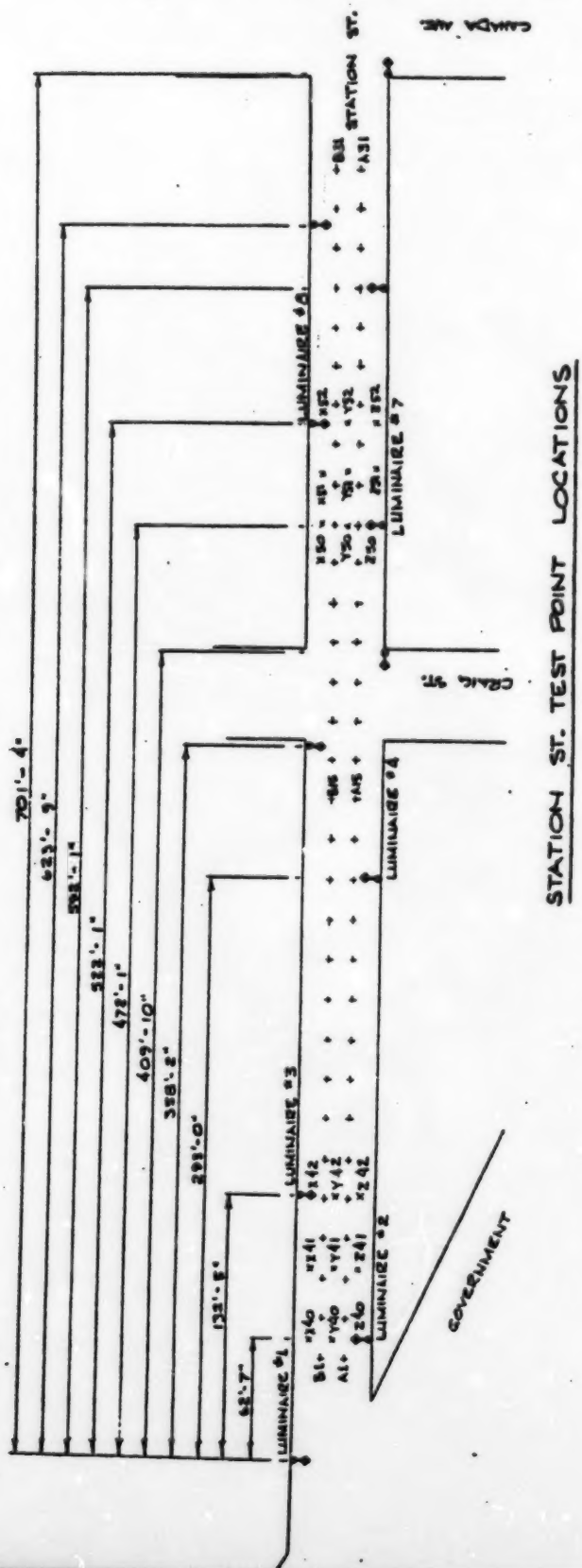
Figure 3: Conditions of 200 Watt High Pressure Sodium System Test

DATE: 20 Jan 1983
TIME: 2230
CITY: Duncan
LOCATION: Station Street
APPARENT DIRT ACCUMULATION: None
WEATHER: Overcast
LAMP WATTAGE: 200 W
LAMP TYPE: High Pressure Sodium
PHOTOMETER USED: Tektronix J-16

New HPS luminaires installed by 23 July 1982.
Luminaires 1-5 inclusive have standard lenses.
Luminaires 6-11 inclusive have special sag glass lenses.

The measurements from both tests have been compiled and an evaluation has been made (see RESULTS).

Figure 4: Map of Station Street



RESULTS

Table 1 has the illuminance readings taken during the two roadway lighting tests and then used to determine the average illuminance of the different systems. The readings are given in footcandles because the Tektronix photometer is calibrated in footcandles; however, the averages are converted to SI units. These SI average illuminances (Eav) and the percent difference between the mercury vapour and high pressure sodium systems were calculated and are given below.

TABLE 1

LIGHT READINGS FOR AVERAGE ILLUMINANCE

Unit = Footcandle

Row / Column	A		B	
	400W MV	200W HPS	400W MV	200W HPS
1	4.71	6.16	2.99	4.50
2	5.02	6.82	3.44	4.59
3	3.44	3.41	2.28	2.53
4	2.02	3.72	2.52	3.72
5	1.60	4.66	3.53	7.99
6	1.46	2.87	2.57	3.79
7	1.27	1.68	1.40	1.74
8	1.57	1.32	1.50	2.04
9	1.34	1.02	1.33	1.28
10	1.03	1.33	1.31	1.83
11	1.35	1.56	1.36	1.57
12	2.68	2.67	1.49	2.85
13	4.90	7.30	3.68	4.08
14	4.46	3.36	3.11	2.73
15	3.24	3.59	3.05	3.16
16	4.04	5.83	6.03	6.34
17	4.68	5.78	6.31	5.67
18	3.85	3.97	3.10	3.01
19	1.86	3.49	2.06	2.48
20	1.63	2.55	1.34	1.72
21	2.10	4.56	1.52	2.58
22	2.95	5.43	2.45	3.15
23	2.51	3.02	2.08	3.12
24	3.00	2.65	5.17	7.41
25	3.39	3.05	4.72	4.62
26	2.83	2.92	2.48	2.98
27	3.94	4.47	3.74	3.61
28	4.62	5.25	4.25	4.92
29	4.21	2.59	6.29	7.60
30	2.98	2.35	5.50	3.80
31	1.70	1.48	1.93	1.49

Average Illuminance:	fc	lux	% diff
1) Mercury Vapour			
a) 1-16	2.68	28.8	0
b) 17-31	3.31	35.6	0
2) High Pressure Sodium			
a) Standard refractor	3.50	37.7	+31
b) Sag glass refractor	3.72	40.0	+12

Columns 1-16 are standard HPS readings and 17-31 are sag glass readings.

The different values for high pressure sodium have been included to permit an evaluation of the two refractors tested.

Calculations made prior to the tests indicated that the high pressure sodium system would provide an 11% increase in average illuminance. Therefore actual levels, as shown below, were higher than expected. This was probably because the existing 400W MV luminaires would have some deterioration not considered in the calculation. However, all illuminance levels exceed 10 lux, as the minimum specified by the IES "Proposed American National Standard Practice for Roadway Lighting" (see Table 2b, page 151).

The additional readings that are shown in Table 2 were used to calculate the average to minimum illuminance ratios (see summary below). Table 3 shows that these ratios are within the 4 to 1 limits set by the IES (see Table 2b, page 151 of "Proposed American National Standard Practice for Roadway Lighting").

Luminaire "brightness" measurements were taken to try and quantify the disability glare that might be seen by a vehicle driver. The meter normally used for these tests failed to operate correctly; therefore the luminance probe with the Tektronix J-16 photometer was used. Measurements by this meter indicated higher luminance values for the HPS standard refractor units and still higher values for the HPS sag glass units. However, this instrument's field of view is greater than desireable so the readings could only be considered as indicative but not absolute.

Subjectively, in a vehicle driver's normal field of view, the standard refractor performed better than the sag glass refractor. For two of the three test positions in this field of view, the high pressure sodium with the standard refractor had only marginally more disability glare than the mercury vapour luminaire. Outside of the driver's normal field view the sag glass refractor generally produced less glare.

TABLE 2

READINGS TO DETERMINE AVERAGE TO MINIMUM ILLUMINANCE RATIOS

Unit = Footcandle

Row / Column	X		Y		Z	
	400W MV	200W HPS	400W MV	200W HPS	400W MV	200W HPS
40	2.63	2.87	4.23	6.85	5.78	6.80
41	2.14	1.74	2.83	3.26	2.63	2.89
42	4.09	5.82	2.73	6.50	1.03	2.42
50	-	1.32	-	5.71	-	7.94
51	-	2.28	-	3.33	-	2.81
52	-	*	-	5.65	-	*

* Reading could not be taken because of parked vehicles.

TABLE 3

AVERAGE TO MINIMUM AND MAXIMUM TO MINIMUM ILLUMINANCE RATIOS

	Average/Minimum	Maximum/Minimum
Mercury Vapour 1-16	2.60:1	5.65:1
HPS Overall 17-31	2.47:1	4.71:1
HPS Standard Refractor	3.43:1	7.83:1
HPS Sag Glass Refractor	2.82:1	6.02:1

APPENDIX I

LM-50 IES Guide for Photometric Measurement of Roadway Lighting Installations

LM-50
Reprinted from January 1975 issue
JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

IES Guide for photometric measurement of roadway lighting installations

Prepared by the
Subcommittee on Photometry of Outdoor Luminaires of the
Testing Procedures Committee of the Illuminating Engineering Society

Foreword—This guide is a revision of the roadway portion of the "IES Guide for Outdoor Illumination Tests." Previously, the guide referred to both sports and roadway installations; however, because of the wide differences in sports and roadway design criteria, the guide was divided and expanded for each application. Here, the guide represents an updating and expansion of the roadway lighting measurement portion to include such material as luminance measurement. In addition to the Testing Procedures Committee, the guide was reviewed by the Measurement and Calculation Subcommittee of the Roadway Lighting Committee.

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Approved by the Board of Directors of the Illuminating Engineering Society, July 1974, as a Transaction of the IES.

1. Introduction

The purpose of this guide is to provide a uniform test procedure in determining and reporting the illumination characteristics of roadway lighting installations. The measurements of those factors necessary in determining the performance of roadway lighting installations are specifically related to the "American National Standard Practice for Roadway Lighting."[1]

2. Conditions of test

2.1 General. The accuracy of field photometry is of a lower order than laboratory photometry because of the inherent inaccuracies of field tests and adverse test conditions encountered. For this reason, it is important to record all the existing conditions at the time of the test, such as, voltage, wattage, age of light source, apparent dirt accumulation, temperature, lamp burning position, atmospheric condition, or any other factor that might affect the results.

2.2 New installations. The luminaires should be clean with new lamps installed. The lamps should be seasoned properly[2] before testing. Luminaires and lamps should be properly installed and adjusted.

2.3 Old installations. If the test is made for the purpose of checking the performance of the installa-

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eling the photometer sensor to minimize errors when the principal source of light is incident at angles greater than 70 degrees as in some roadway lighting installations. The sensor should not be more than six inches (0.15 meter) above the street surface.

Illumination readings are taken at centers of the test areas. Only the readings taken at the basic test stations should be used in the calculation of the average values. However, other measurements may be taken at points of special significance, such as along the curb line and center line, halfway between or immediately under luminaires, or at points where a maximum or minimum intensity is anticipated. Readings should only be made when the pavement is dry.

Readings taken on vertical or 10-degree sloping surfaces at other than six inches (0.15 meter) above the road surface should have the actual height and orientation of sensor specified in the test report (see Section 5).

4.2 Location of test stations. Test stations should be systematically chosen in such manner as to correctly represent the illumination pattern. The test span should be divided into an even number of equal rectangular or square test areas—the luminaires located at the boundary lines of such areas, rather than over the centers of the areas. Illumination readings are taken at centers of the test areas. The mean for the entire surface can be computed from the average horizontal illumination for test stations so disposed if a sufficient number is selected. The span should include at least three luminaires. The luminaire is not necessarily located at the boundary of the test areas in the lateral or crosswise direction.

In the crosswise direction, it is advisable to locate the station in the centers of traffic lanes. For this purpose, a traffic lane is considered to be approximately 12 feet (3.7 meters) wide.

In the lengthwise direction, divide the distance between luminaires into an even number of divisions of about 10-foot (3.1-meter) intervals. For mounting heights of 50 feet (15.2 meters) or higher, intervals of 2½ M/H ratios are satisfactory for test stations. Readings are then taken at the middle of each rectangle thus formed. Typical arrangements of roadway lighting luminaires and test stations are shown in Fig. 1.

4.3 Luminance measurements. The aim of measuring the road surface luminance is to determine the values of luminance as they are seen by a vehicle driver. Such measurements can be made either at singular points or made to give average values of a selected wide field of views. They can also be made from a static or fixed viewing point, or from a dynamic or moving viewing point. Researchers are presently working on standardized methods for: (1) presentation of pavement directional reflectance; (2) describing the roadway geometry; and (3) ways to classify pavements and other pertinent criteria for the measurement of luminances. (For further information on luminance measurements, see the appropriate CIE publication,[5,6] and Appendix E of the "American National Standard Practice for Roadway Lighting."[1])

5. Test report

The test report should present the significant data in a manner that will permit further derivation of useful information. It is recommended that the following items be included:

(1) Location (city, roadway and section thereof).

(2) Date and time of measurement.

(3) Detailed discription of installation and lighting equipment (including lamp and ballast type).

(4) Actual mounting height, spacing, arrangement and special circumstances, including any interferences, surrounding conditions, extraneous light sources, etc.

(5) Diagram showing test stations with dimensions.

(6) Electrical operating conditions.

(7) Condition of luminaires, other equipment, and the number of operation days.

(8) Weather and sky conditions.

(9) Tabulation of test data.

(10) Record of special measurements.

(11) Ratio of maximum and minimum to average, and ratio of maximum to minimum and average of reading stations.

(12) Description of instruments used (including manufacturer's name and model number), position of instrument receptor for tests and calibration, and source.

(13) Names of witnesses taking measurements.

References

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4. Committee on Testing Procedures of the IES, "IES guide for the selection, care and use of electrical instruments in the photometric laboratory," ILLUMINATING ENGINEERING, Vol. 63, No. 7, July 1968, p. 376.

5. "International recommendations for the lighting of public thoroughfares," CIE Publication No. 12, International Commission on Illumination (CIE), C/O National Bureau of Standards, Washington, D.C. 20234, 1965.

6. "Photometry of luminaires for street lighting," CIE Publication No. 27, International Commission on Illumination (CIE), C/O National Bureau of Standards, Washington, D.C. 20234, 1974.